

1.28: SOLAR /1034-79/02

Alpha 1034-302

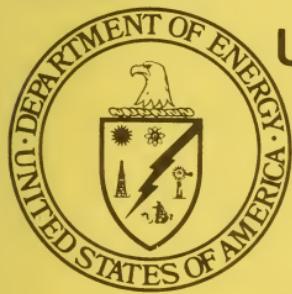
SOLAR/1034-79/02



# Monthly Performance Report

ALPHA CONSTRUCTION CO.

FEBRUARY 1979



## U.S. Department of Energy

National Solar Heating and  
Cooling Demonstration Program

National Solar Data Program

NOTICE

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MONTHLY PERFORMANCE REPORT

ALPHA CONSTRUCTION COMPANY

FEBRUARY 1979

I. SYSTEM DESCRIPTION

The Alpha Construction Company site is a single-family residence in Canton, Ohio. Solar energy is used for space heating the home and preheating domestic hot water (DHW). The solar energy system has an array of flat-plate collectors with a gross area of 428 square feet. The array faces south at an angle of 37 degrees to the horizontal. Air is the transfer medium that delivers solar energy from the collector array to storage and to the space heating and hot water loads. Solar energy is stored in the basement in a 510-cubic-foot bin containing 50,100 pounds of rock. The bin has concrete block walls and polyurethane insulation. Preheated city water is stored in an 80-gallon preheat storage tank and supplied, on demand, to a conventional 52-gallon DHW tank. When solar energy is insufficient to satisfy the space heating load, a heat pump in the air-handling unit provides auxiliary energy for space heating. Similarly, an electrical heating element in the DHW tank provides auxiliary energy for water heating. The system, shown schematically in Figure 1, has four modes of solar operation.

Mode 1 - Collector-to-Space Heating: This mode activates when the collector is operating, a space heating demand exists, and the plenum temperature at the top of storage is above the minimum value suitable for supplying heat to the house. Heated air is circulated through the house by the air-handling unit before being returned to the collector.

Mode 2 - Collector-to-Storage: This mode activates when the collector is operating and there is either no demand for space heating or the plenum temperature at the top of storage is below the minimum value for supplying heat to the house.

Mode 3 - Storage-to-Space Heating: This mode activates when there is a demand for space heating, and the plenum temperature at the top of storage is above the minimum value for supplying heat to the house. The fan in the air-handling unit draws air from the bin, circulating it through the house and back to storage.

Mode 4 - Domestic Water Preheating: This mode activates when the temperature at the top of the collector indicates a minimum value for hot water heating, which must be above the plenum temperature at the bottom of storage.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was unoccupied during the month of February; however the solar energy system operated continuously during the month. Solar energy satisfied

- 1001 COLLECTOR PLANE TOTAL INSOLATION
- T001 OUTDOOR TEMPERATURE
- T600 INDOOR TEMPERATURE

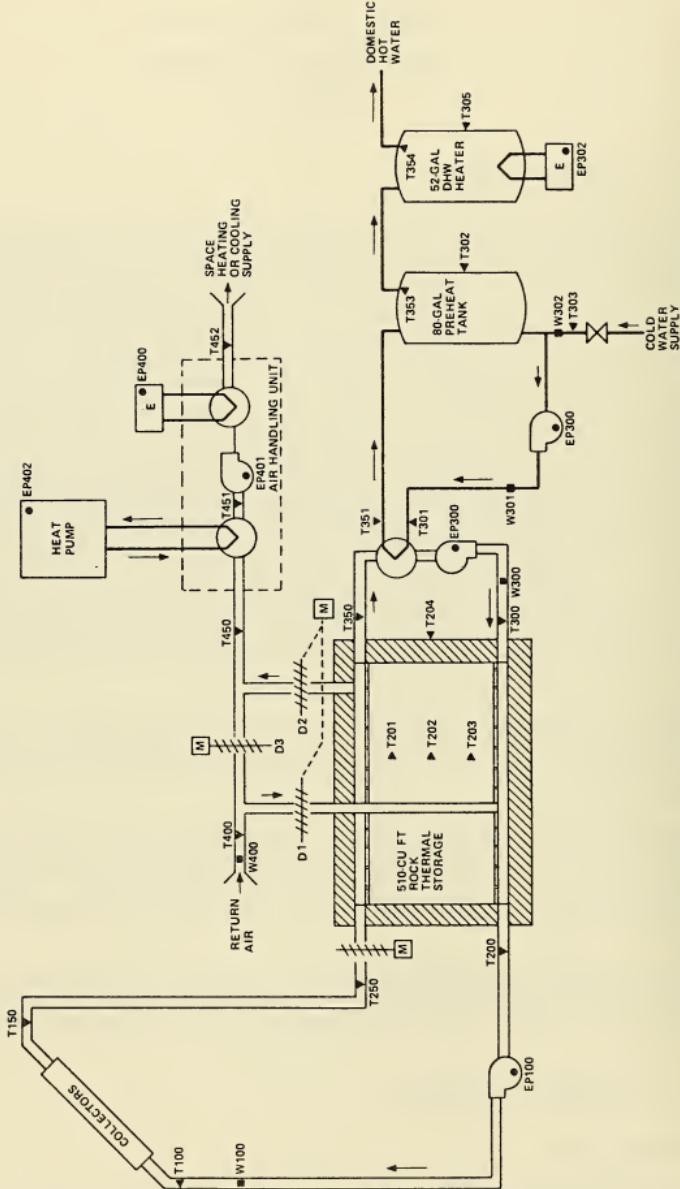


Figure 1. ALPHA CONSTRUCTION CO. SOLAR ENERGY SYSTEM SCHEMATIC

1 percent of the space heating requirements. The solar energy system incurred an electrical energy expense of 0.25 million Btu.

#### WEATHER CONDITIONS

During the month total incident solar energy on the collector array was 9.6 million Btu for a daily average of 799 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area during February of 947 Btu per square foot for a south-facing plane with a tilt of 37 degrees to the horizontal. The average ambient temperature during February was 18°F as compared with the long-term average for February of 28°F. The number of heating degree-days for the month (based on a 65°F reference) was 1327, as compared with the long-term average of 1044.

#### THERMAL PERFORMANCE

System - During February the solar energy system performed somewhat poorer than expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as inputs. Solar energy collected was 2.5 million Btu versus an estimated 3.2 million Btu. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 0.17 million Btu. System total solar fraction was 1 percent versus an estimated 31 percent.

Collector - The total incident solar radiation on the collector array for the month of February was 9.6 million Btu. During the period the collector loop was operating, the total insolation amounted to 7.5 million Btu. The total collected solar energy for the month of February was 2.5 million Btu, resulting in a collector array efficiency of 26 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 2.4 million Btu, while solar energy delivered from the collector array directly to the loads amounted to 0.072 million Btu. Energy loss during transfer from the collector array to storage and loads was 0.024 million Btu. This loss represented 1 percent of the energy collected. Operating energy required by the collector loop was 0.17 million Btu.

Storage - Solar energy delivered to storage was 2.4 million Btu. There were 0.093 million Btu delivered from storage to the space heating subsystem. Energy loss from storage was 1.9 million Btu. This loss represented 81 percent of the energy delivered to storage. The storage efficiency was 19 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 71°F.

DHW Load - Because the home was unoccupied in February there was no requirement for hot water. A total of 0.072 million Btu of solar energy was used to heat the water in the preheat tank. The DHW subsystem consumed a total of 0.11 million Btu of operating energy resulting in an energy expense of 0.11 million Btu. An additional 0.31 million Btu of auxiliary electrical energy

was used by the hot water tank to maintain the temperature. The average temperature of the water in the DHW tank was 120°F.

Space Heating Load - The space heating requirement for the unoccupied home during February was 9.3 million Btu. The solar energy system provided 0.093 million Btu or 1 percent of this requirement. The remaining load of 9.2 million Btu was satisfied by an auxiliary electrical heat pump and an electrical heating element at an electrical consumption of 5.3 million Btu. The space heating subsystem consumed an additional 1.7 million Btu of operating energy. A net electrical energy savings of 0.030 million Btu was obtained from the solar portion of the space heating subsystem.

## OBSERVATIONS

The solar energy site was unoccupied during the month of February and presented a minimum space heating load due to a thermostat set at 57°F. The daily average insolation was slightly lower than is expected in February, while the average temperature was 10°F colder than the long-term average. On 10 days the total daily insolation was greater than 1000 Btu per square foot. On only five days, however, was the temperature in storage sufficient to act as a source for space heating and then only minimally. Unmeasurable energy escaped into the conditioned space and outside environment causing storage to lose most of the energy collected during the month. The 1.9 million Btu lost from storage, if added to the measured space heating load of 9.3 million Btu, exceeds the estimated space heating load of 10.1 million Btu (based on UA value of the house).

The DHW preheat subsystem expended more operating energy than the amount of solar energy transferred to the DHW preheat tank; this pattern has been consistent throughout the heating season. The lack of a hot water load due to the unoccupied home may partially account for this.

The configuration of the DHW subsystem preheat loop permits energy transfer to the preheat tank only during times when collection is occurring. A separate air blower is required by this subsystem, adding significantly to the operating energy costs. During periods of heating from storage, an induced air flow occurs through the DHW preheat loop. Some of the unmeasurable energy loss from storage may be escaping through this air path. During the cooling season the storage subsystem must be operated to allow operation of the DHW preheat subsystem. Energy not utilized by the DHW subsystem is collected in storage. Energy losses from storage to the conditioned space add to the cooling load, reducing any savings obtained by the DHW subsystem. Based upon the apparent ineffectiveness during the heating season and the operating costs during the summer, it may be worth reconfiguring or deactivating the DHW subsystem at this site.

## ENERGY SAVINGS

The solar energy system incurred a total electrical energy expense of 0.25 million Btu. The space heating subsystem provided a savings of 0.03 million Btu but this was eliminated due to the expense of operating the DHW subsystem (0.11 million Btu) and the collection subsystem (0.17 million Btu).

### III. ACTION STATUS

Boeing conducted a preliminary air-mapping survey in October which revealed significant leaks in the energy collection and storage subsystems. Sealing the accessible leaks would only provide minimal improvement.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM  
 MONTHLY REPORT  
 SITE SUMMARY

SITE: ALPHA CONSTRUCTION COMPANY  
 REPORT PERIOD: FEBRUARY, 1979

SITE/SYSTEM DESCRIPTION:  
 THE SOLAR ENERGY SYSTEM PROVIDES FOR SPACE HEATING OF A SINGLE FAMILY DWELLING. THE SYSTEM ALSO PROVIDES ENERGY TO AN 80 GALLON HOT WATER PREHEAT TANK. STORAGE IS 510 CUBIC FEET OF GRAVEL. A HEAT PUMP AND ELECTRIC STRIP HEATERS PROVIDE AUXILIARY SPACE HEATING.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY  
 COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE  
 AVERAGE BUILDING TEMPERATURE  
 ECSS SOLAR CONVERSION EFFICIENCY  
 ECSS OPERATING ENERGY  
 TOTAL SYSTEM OPERATING ENERGY  
 TOTAL ENERGY CONSUMED

9.586 MILLION BTU  
 22376 BTU/SQ. FT.  
 2459 MILLION BTU  
 5741 BTU/SQ. FT.  
 18 DEGREES F  
 57 DEGREES F  
 0.02 MILLION BTU  
 0.166 MILLION BTU  
 1.943 MILLION BTU  
 9.983 MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING
LCAD	0.000	9.290	N.A.
SOLAR FRACTION	0.13	1	N.A.
SOLAR ENERGY USED	0.072	0.093	N.A.
OPERATING ENERGY USED	0.113	0.664	N.A.
AUX. THERMAL ENERGY	0.305	4.592	N.A.
AUX. ELECTRIC FUEL	0.305	5.276	N.A.
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.
ELECTRICAL SAVINGS	-0.113	0.30	N.A.
FCSSIL SAVINGS			N.A.

SYSTEM PERFORMANCE FACTOR:

\* DENOTES UNAVAILABLE DATA  
 @ DENOTES NULL DATA  
 N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 26, 1978,  
 SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM  
 MONTHLY REPORT  
 SITE SUMMARY

SITE: ALPHA CONSTRUCTION COMPANY  
 REPORT PERIOD: FEBRUARY, 1979

SITE/SYSTEM DESCRIPTION:

THE SOLAR ENERGY SYSTEM PROVIDES FOR SPACE HEATING OF A SINGLE FAMILY DWELLING. THE SYSTEM ALSO PROVIDES ENERGY TO AN 80 GALLON HOT WATER PREHEAT TANK. STORAGE IS 510 CUBIC FEET OF GRAVEL. A HEAT PUMP AND ELECTRIC STRIP HEATERS PROVIDE AUXILIARY SPACE HEATING.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY

COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE  
 BUILDING TEMPERATURE  
 EXCESS SOLAR CONVERSION EFFICIENCY  
 OPERATING ENERGY  
 TOTAL SYSTEM OPERATING ENERGY  
 TOTAL ENERGY CONSUMED

10.113 GIGA JOULES  
 254399 KJ/SQ.M.  
 65193 GIGA JOULES  
 -8 DEGREES C  
 1.4 DEGREES C  
 0.02 GIGA JOULES  
 2.050 GIGA JOULES  
 15.532 GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING
LOAD	0.000	9.801	N.A.
SOLAR FRACTION	0.13	1	N.A.
SOLAR ENERGY USED	0.076	0.098	N.A.
OPERATING ENERGY	0.119	1.756	N.A.
AUX. THERMAL ENG	0.322	4.845	N.A.
AUX. ELECTRIC FUEL	0.322	5.566	N.A.
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.
ELECTRICAL SAVINGS	-0.119	0.032	N.A.
FOSSIL SAVINGS	N.A.	N.A.	N.A.

SYSTEM PERFORMANCE FACTOR:

\* DENOTES UNAVAILABLE DATA

@ DENOTES NULL DATA

N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT  
 OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,  
 SOLAR/0004-78/18

SOLAR/1034-79/02

## SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT  
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)SITE: ALPHA CONSTRUCTION COMPANY  
REPORT PERIOD: FEBRUARY, 1979

SOLAR/1034-70/02

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU		ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
					ECSS	ECSS ENERGY REJECTED MILLION BTU		
1	0.145	55	0.000	N	0.002	0.000	0.000	0.000
2	0.344	111	0.005	0	0.011	0.000	0.000	0.015
3	0.219	20	0.003	T	0.009	0.000	0.000	0.013
4	0.907	16	0.007	0	0.011	0.000	0.000	0.018
5	1.028	2	0.005	4	0.012	0.000	0.000	0.004
6	0.662	8	0.020	P	0.012	0.000	0.000	0.030
7	0.111	23	0.000	P	0.000	0.000	0.000	0.000
8	0.686	11	0.003	L	0.010	0.000	0.000	0.004
9	0.696	3	0.005	I	0.010	0.000	0.000	0.007
10	0.588	1	0.002	C	0.010	0.000	0.000	0.003
11	0.649	5	0.043	A	0.010	0.000	0.000	0.064
12	0.060	13	0.000	B	0.000	0.000	0.000	0.000
13	0.089	15	0.000	U	0.000	0.000	0.000	0.000
14	0.067	10	0.000	E	0.000	0.000	0.000	0.000
15	0.055	22	0.000	0	0.007	0.000	0.000	0.004
16	0.023	11	0.001	0	0.007	0.000	0.000	0.004
17	0.531	-1	0.008	0	0.013	0.000	0.000	0.015
18	0.171	19	0.008	0	0.007	0.000	0.000	0.000
19	0.271	16	0.000	0	0.007	0.000	0.000	0.001
20	0.289	23	0.023	0	0.013	0.000	0.000	0.078
21	0.260	36	0.025	0	0.009	0.000	0.000	0.423
22	0.238	35	0.000	0	0.009	0.000	0.000	0.001
23	0.104	44	0.000	0	0.001	0.000	0.000	0.002
24	0.092	36	0.000	0	0.001	0.000	0.000	0.000
25	0.043	32	0.000	0	0.000	0.000	0.000	0.000
26	0.013	27	0.000	0	0.000	0.000	0.000	0.000
27	0.529	29	0.007	0	0.007	0.000	0.000	0.013
28	0.708	32	0.011	0	0.013	0.000	0.000	0.015
SUM	9.586	-	0.165	N.A.	0.166	N.A.	-	N.A.
AVG	0.342	18	0.006	N.A.	0.006	N.A.	0.017	N.A.
NBS ID	Q001	N113			Q102			N111

\* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

## SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT  
COLLECTOR PAY PERFORMANCE

SITE: ALPHA CONSTRUCTION COMPANY  
REPORT PERIOD: FEBRUARY 1979

SOLAR/1034-79/02

\* DENOTES UNAVAILABLE DATA

UNAVAILABLE DATA

DENOTES NOT APPLICABLE DATA.

## SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT  
STORAGE PERFORMANCESOLAR/1034-79/02  
SITE: ALPHA CONSTRUCTION COMPANY  
REPORT PERIOD: FEBRUARY, 1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
					SOLAR/1034-79/02
1	0.005	0.000	-0.016	53	-3.047
2	0.131	0.000	-0.078	56	0.680
3	0.121	0.000	-0.119	64	0.641
4	0.188	0.000	-0.093	73	0.636
5	0.208	0.000	-0.061	81	0.398
6	0.112	0.017	-0.063	84	-2.386
7	0.000	0.000	-0.054	77	-1.000
8	0.131	0.000	-0.019	77	0.414
9	0.153	0.000	-0.030	80	-0.000
10	0.165	0.000	-0.069	80	-0.000
11	0.000	0.000	-0.047	73	-1.000
12	0.000	0.000	-0.040	66	1.000
13	0.000	0.000	-0.033	66	1.000
14	0.000	0.000	-0.028	63	1.000
15	0.058	0.000	-0.033	61	-0.048
16	0.222	0.000	-0.146	68	0.655
17	0.006	0.000	-0.037	73	-6.432
18	0.057	0.000	-0.004	71	-0.073
19	0.057	0.000	-0.135	77	0.487
20	0.250	0.011	-0.135	73	1.000
21	0.000	0.025	-0.046	71	0.733
22	0.063	0.000	-0.036	72	-3.497
23	0.069	0.000	-0.024	70	-14.158
24	0.002	0.000	-0.019	68	-1.000
25	0.000	0.000	-0.021	66	1.000
26	0.000	0.000	-0.072	68	0.610
27	0.118	0.000	-0.170	81	0.680
28	0.253	0.003	-0.170	-	-
SUM	2.363	0.093	0.366	-	-
AVG	0.084	0.003	0.013	71	0.194
NBS ID	Q2CO	0201	Q202	N108	

\* DENOTES UNAVAILABLE DATA.

a DENOTES NULL DATA.  
N.A. DENOTES NOT APPLICABLE DATA.

## SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT  
HOT WATER SUBSYSTEM

SITE: ALPHA CONSTRUCTION COMPANY  
REPORT PERIOD: FEBRUARY, 1979

SOLAR/1034-79/02

\*\* DENOTES UNAVAILABLE DATA.  
@ DENOTES NULL DATA.  
- DENOTES NOT APPLICABLE.

## SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT  
SPACE HEATING SUBSYSTEMSITE: ALPHA CONSTRUCTION COMPANY  
REPORT PERIOD: FEBRUARY, 1979

SOLAR/1034-79/02

DAY	SPACE HEATING LOAD BTU	SOLAR FRA. OF LOAD PCT	OPER. ENERGY USED MILLION BTU	AUX THERMAL FUEL MILLION BTU	AUX ELECT. FUEL MILLION BTU	ELECT. ENERGY SAVINGS MILLION BTU		FOSSIL ENERGY SAVINGS MILLION BTU	BLDG AMR TEMP DEG. F	BLDG AMR TEMP DEG. F
						DEG. F	DEG. F			
1	351	0	0.000	0.077	0.136	0.168	0.224	0.000	56	15
2	372	0	0.000	0.058	0.116	0.140	0.186	0.000	57	11
3	280	0	0.000	0.054	0.162	0.286	0.267	0.000	59	16
4	318	0	0.000	0.066	0.263	0.347	0.347	0.000	58	12
5	428	0	0.017	0.065	0.244	0.286	0.267	0.000	57	8
6	421	0	0.000	0.062	0.281	0.311	0.311	0.000	57	23
7	276	0	0.000	0.067	0.146	0.172	0.172	0.000	57	11
8	327	0	0.000	0.076	0.283	0.341	0.341	0.000	57	13
9	477	0	0.000	0.097	0.517	0.517	0.517	0.000	57	11
10	426	0	0.000	0.060	0.257	0.227	0.227	0.000	58	15
11	513	0	0.000	0.088	0.292	0.324	0.324	0.000	58	13
12	513	0	0.000	0.088	0.263	0.298	0.298	0.000	57	10
13	498	0	0.000	0.088	0.263	0.298	0.298	0.000	57	10
14	498	0	0.000	0.066	0.215	0.247	0.247	0.000	57	22
15	499	0	0.000	0.080	0.215	0.247	0.247	0.000	57	11
16	427	0	0.000	0.075	0.287	0.312	0.312	0.000	57	11
17	566	0	0.000	0.084	0.295	0.328	0.328	0.000	57	9
18	518	0	0.000	0.066	0.202	0.240	0.240	0.000	57	16
19	275	0	0.000	0.034	0.127	0.127	0.127	0.000	58	23
20	214	0	0.025	0.024	0.126	0.139	0.139	0.000	56	36
21	218	0	0.000	0.022	0.032	0.044	0.044	0.000	56	35
22	114	0	0.000	0.010	0.010	0.023	0.023	0.000	56	44
23	158	0	0.000	0.024	0.039	0.053	0.053	0.000	56	36
24	134	0	0.000	0.024	0.039	0.053	0.053	0.000	56	36
25	296	0	0.000	0.050	0.127	0.153	0.153	0.000	57	32
26	337	0	0.000	0.071	0.113	0.148	0.148	0.000	59	27
27	357	0	0.000	0.032	0.048	0.064	0.064	0.000	61	29
28	141	0	0.003	0.032	0.045	0.059	0.059	0.000	61	32
SUM	9,290	-	0.093	1	6.64	4.592	5.276	N.A.	0.030	N.A.
AVG	0.332	1	0.003	0	0.059	0.164	0.188	N.A.	0.001	N.A.
NBS	N402	N400	Q400	Q403	Q401	Q410	Q415	Q417	N406	N113

\* DENOTES UNAVAILABLE DATA.

N.A. DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

## SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT  
ENVIRONMENTAL SUMMARYSITE: ALPHA CONSTRUCTION COMPANY  
REPORT PERIOD: FEBRUARY, 1979

SOLAR/1034-70/02

DAY OF MONTH	TOTAL INSOLATION BTU/SQ. FT	DIFFUSE INSOLATION BTU/SQ. FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.	NOT A P L T C A B L E
1	339	N	15	19	N	N	NOT	
2	803	O	11	20	O	O	NOT	
3	512	T	20	29				
4	2116	A	16	18			A	
5	2399	P	12	10			P	
6	1544	P	8	*			P	
7	1259	L	23	28			L	
8	1602	L	11	15			L	
9	1626	I	3	12			I	
10	1373	C	1	10			C	
11	1515	A	5	15			A	
12	140	B	13	18			B	
13	208	E	15	14			E	
14	156		10	12				
15	128		22	26				
16	1540		11	16				
17	1238		11	16				
18	1400		6	12				
19	632		16	22				
20	673		23	33				
21	139		36	40				
22	556		35	36				
23	244		44	46				
24	215		36	36				
25	100		32	32				
26	130		27	28				
27	1234		29	35				
28	1653		32	42				
SUM	22376	N.A.	-	-			-	
AVG	799	N.A.	18	23			N.A.	N.A.
NBS ID	Q001		N113				N115	N114

\* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.









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